Desconstructing van Fraassen's observable/unobservable dichotomy

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Abstract

As it is well-known, van Fraassen builds constructive empiricism, his alternative to scientific realism, on top of his observable/unobservable dichotomy. Here it will be defended that this dichotomy cannot be made to stand.

1 Introduction

In *The Scientific Image*, Bas C. van Fraassen presents what he regards to be an empiricist anti-realism. Van Fraassen develops his views against scientific realism. With the realists, van Fraassen shares a commonsensical realism about the world (i.e. there are things, processes, and events around us that we perceive with our senses, and all of this is real). Everything that we perceive with our bare senses van Fraassen calls observable. As it is well-known, physical theories postulate mathematically structured concepts like space, time, fields, and so on. There are versions of scientific realism (which I will call entity realism) that tend to regard postulated entities like electrons as ontologically meaningful. While sharing with realists a commonsensical realism, van Fraassen does not goes as far as accepting that putative theoretical entities might be concrete entities (i.e. real). Since the breakdown of the theoretical terms/observational terms dichotomy (theory/observation dichotomy), realists made their case for the possibility of observing what under logical positivism were theoretical terms. For example, Grover Maxwell (1962) considers that due to the impossibility of making a clear theory/observation distinction (since according to Maxwell there is a continuous transition from observable to unobservable) we cannot consider 'electron' to be a theoretical term. Regarding the theory/observation distinction van Fraassen remarks that

> such expressions as 'theoretical entity' and 'observable-theoretical dichotomy' are, on the face of it, examples of category mistakes. Terms or concepts are theoretical (introduced or adapted for the purpose of theory construction); entities are observable or unobservable. This may seem a little point, but it separates the discussion into two issues. Can we divide our language into a theoretical and non-theoretical part? On the other hand, can we classify objects and events into observable and unobservable ones? (van Fraassen 1980, 14)

Van Fraassen accepts the consolidated view that the answer to the first question is negative, but by disentangling from it the second question he can give a positive answer to this question enabling him to promote a new dichotomy that, like the previous one before, can be used, for example, as a barrier to the scientific realist belief in the existence of electrons. With his new dichotomy van Fraassen has the instrument to promote an anti-realist stance. Theories only need to save observable regularities, in this case they have empirical adequacy. This does not imply that the scientific image we are immersed in when accepting a theory has ontological significance regarding the unobservable aspects of the world; we can be agnostic, since the 'immersion in the theoretical world-picture does not preclude 'bracketing' its ontological implications' (van Fraassen 1980, 81); also to van Fraassen this dichotomy has implications regarding our epistemic attitudes: it suggests that our knowledge is limited: 'the amount of believe involved in [a theory] acceptance is typically less according to anti-realism' (van Fraassen 1980, 13).

2 The downfall of the observable/unobservable dichotomy

In this section I will provide an argument that shows that van Fraassen fails to draw a principled distinction between the observable and the unobservable. I will start in subsection 2.1 to review the details of van Fraassen's argumentation against Maxwell's argument, and his proposition of an observable/unobservable dichotomy. Then I will address the possible threat of circularity in van Fraassen's constructive empiricism due to his view of observable as observable-to-us. Finally I will address arguments by Hacking and Teller, and van Fraassen's reaction to these. In sections 2.2 and 2.3 I will set forward an argument showing that van Fraassen's observable/unobservable dichotomy is not tenable.

2.1 Harming up

Van Fraassen sets forward his observable/unobservable dichotomy against Maxwell's argument of the continuum. Maxwell developed his argument in the context of criticizing the theory/observation dichotomy. Van Fraassen called the attention to the fact that it is possible (in his view) to separate the observable/unobservable dichotomy from the theory/observation dichotomy. Van Fraassen accepts that the theory/observation dichotomy is not feasible, but considers that this does not entails anything regarding the observable/unobservable distinction. Maxwell argument goes as follows:

> there is, in principle, a continuous series beginning with looking through a vacuum and containing these as members: looking though a windowpane, looking though glasses, looking through binoculars, looking through a low-power microscope, looking through a high-power microscope, etc., in the given order. The important consequence is that, so far, we are left without criteria which would enable us to draw a non-arbitrary line between 'observation' and 'theory'. (Maxwell 2009 [1962], 453)

Applied to the observable/unobservable dichotomy, Maxwell's argument of the continuum would imply that there would be no criteria to make the distinction between observable and unobservable. Van Fraassen rejects (I think correctly) Maxwell's argument, because Maxwell does not present anything to justify and characterize what this supposed 'continuum' might be (not even in the case of his example of a set of lenses and microscopes). Van Fraassen considers that even if observable is a vague predicate due to the fact that it is not possible to draw the line between the observable and the unobservable clearly, this does not imply that the dichotomy is meaningless. According to van Fraassen the dichotomy is tenable if we can present clear examples of observable and unobservable things, events, etc. To van Fraassen the moons of Jupiter are observable, not because we can see them using a telescope, but because an astronaut could see them directly. It is this seeing with the naked eye (or other non-aided modes of perception) that van Fraassen calls observation. To van Fraassen an electron (if existing) is not observable.

Since the 'continuum' argument does not hold (since to van Fraassen there are clear examples of observables and putative unobservables) there is no reason to accept the scientific realist view that in a cloud/bubble chamber we *detect* electrons. What we perceive are bubbles; this with the right (or in van Fraassen's view, wrong) metaphysical commitment can be taken to imply the detection of a putative microscopic entity. However, according to van Fraassen, there is no solid argument leading us to accept this conclusion.

In his discussion of the observable/unobservable dichotomy, van Fraassen mentions that, since observation refers to him to perception, the limitation on what is observable (i.e. the separation between the observable and the unobservable) is related to 'our limitations *qua* human being' (van Fraassen 1980, 17), which are described by scientific theories of perception. To van Fraassen the acceptance criteria for a theory is its empirical adequacy to what is observable. Since to van Fraassen to be observable is to be observable-to-us, and it is science that tells us what we can regard to be observable, there seems to be a problem of circularity in the definition of empirical adequacy

of a theory (see, e.g. Musgrave 1985, 207-9; Muller 2004; Dicken and Lipton, 2006). Van Fraassen addresses this line of criticism in several places (see, e.g. van Fraassen 1985, 255-6; Monton and van Fraassen 2003; Muller and van Fraassen 2008). I will consider only the views presented in Monton and van Fraassen (2003), which I consider to be the most clear statement of van Fraassen's views concerning the threat of circularity.

As we have seen, in *The Scientific Image*, van Fraassen is clear when saying that observable is observable-to-us. This means that what is observable can change. According to van Fraassen what is observable depends on the epistemic community. *If the epistemic community changes (for example due to the evolution of the specie) the 'line' between the observable and the unobservable can change*. It is important to notice that this is a criterion that is independent of the accepted scientific theories (and what they might say about perception). According to van Fraassen the observable/unobservable distinction is theory-independent. In particular van Fraassen considers that 'our opinions about what is observable will change as science changes. But that does not mean that what is observable changes too' (Monton and van Fraassen 2003, 411). The situation is such that in practice we need to rely on scientific theories to define what is observable; but *in principle, independently of what the epistemic community is, what can be perceived (observed) by members of the community is theory-independent* (Monton and van Fraassen 2003, 414).

This is an important point that will be relevant for the argument I will set forward against the observable/unobservable dichotomy. As in the case of the discussion of Maxwell's argument, van Fraassen is clear in saying that *it is not possible to draw the line between the observable and the unobservable clearly*; van Fraassen even considers that *since what is observable depends on the epistemic community (i.e. us), if we change, at a biological level that affects our perception, there can be a shift in the 'line' between the observable and the unobservable*. Again we must bare in mind that to van Fraassen this does not entail any problem to his observable/unobservable dichotomy since: (1) contrary to Maxwell's view there seems to be no meaningful continuous series connecting bare-vision with, for example, 'seeing' with a electronic microscope (van Fraassen 1980, 16); (2) there are, according to van Fraassen, clear examples of entities that if existing would be unobservable. As mentioned, to van Fraassen 'electron' is a clear example of a putative unobservable entity: 'while the particle is detected by means of the cloud chamber, and the detection is based on observation, it is clearly not a case of the particle's being observed' (van Fraassen 1980, 17).

Since with the *The Scientific Image* van Fraassen became an influential exponent of anti-realism, in part there was a shift of the burden of proof to the realist camp. An important contra-argumentation was made by Ian Hacking, which put forward two (related) arguments for the observability of the unobservable. In the coincidence argument Hacking considers two samples of blood cells that are (to Hacking but not to van Fraassen) seen with two different microscopes, a light microscope and an electron microscope. The slices of blood cells are put on a microscopic grid (which importantly for my later argument is used to calibrate the electron microscope; see Seager 1995, 466). In both cases we see identical visual configurations. According to Hacking

> two physical processes – electron transmission and fluorescent re-emission – are used to detect the bodies. These processes have virtually nothing in common between them. They are essentially unrelated chunks of physics. It would be a preposterous coincidence if, time and again, two completely different physical processes produced identical visual configurations which were, however, artifacts of the physical processes rather than real structures in the cell. (Hacking 1983, 201)[1]

[1] Van Fraassen dismisses this argument simply by calling the attention to the fact that 'we refer to two different sorts of instruments, so the sameness in the outputs must be attributed principally to similarities among the inputs. But no one doubts that it is in each case *blood samples* and not different kind of physical systems that were fed into the machines. This conclusion warrants no inference about the reality of the imputed unobservable structure' (van Fraassen 1985, 298).

This argument from coincidence is reinforced by what Hacking calls the argument of the grid. A barely visible piece of metal is supposed to be engraved with a checkerboard design through a particular technology that uses a large scale (more exactly a 'manipulative-by-us' scale) drawing of a square grid. According to Hacking, 'I know what I see through the microscope is veridical because we *made* the grid to be just that way. I know that the process of manufacture is reliable, because we can check the results with the microscope' (Hacking 1983, 203).

Van Fraassen (I think correctly) dismisses Hacking's argument due to its circularity (van Fraassen 1985, 297-8). According to van Fraassen, 'it is no argument to say "I know that what I see through the microscope is veridical because we *made* the grid to be just that way," since the premise needs to imply what is under dispute (that we *successfully* made the object to be that way) ' (van Fraassen 1985, 298).[2] that is, we have a particular technological practice that is supposed to create micro-structures (that are unobservable). The only way we have to verify this is through a microscope, i.e. we must take for granted that the microscope enables seeing the unobservable (and according to van Fraassen there is no non-metaphysical argument that proves this). On the other hand if we use the supposed micro-grid to say that the microscope enables looking into the unobservable, we are (without any independent argument) accepting that a complex technological practice creates a defined micro-structure.

Hacking's arguments are, according to van Fraassen, unable to demonstrate that the microscopes are windows into the unobservable, and van Fraassen's distinction between the observable and the unobservable can be maintained unaltered.

If we do not see through/with a microscope what do we do then? According to van Fraassen the microscope (or any instrument used in experimental research) creates new observable phenomena:

> this is meant to be a change in view: assimilate those instruments as well, not to windows into the nether world, but to experimental arrangements that produce telling new effects for us to see and for us to give a place in our representations of the world. The instruments used in science can be understood as not revealing what exists behind the observable phenomena, but as creating new observable phenomena to be saved. (van Fraassen 2001 , 154-5)

Paul Teller, while accepting this 'phenomena creation' view regarding most instruments, considers that there are important exceptions (Teller 2001). For example, to Teller the stethoscope and the (light) microscope enable to ear and see unobservable phenomena:

> The details of heart murmurs and wheezing sounds symptomatic of damaged heart valves and pneumonia can not be distinguished by listening with ones ear pressed to the patient's chest. For these phenomena a stethoscope is required. (Teller 2001, 132)

> We use microscopes to become aware of paramecia, mitochondria, cell walls ... not to produce images of which we separately become aware and then interpret as images of these things. (Teller 2001, 133)[3]

Van Fraassen does not accept Teller's views.[4] In any case he does not consider that the possibility of conceding to the view of optical microscopes as windows affects in any relevant way his views:

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[2] Van Fraassen calls the attention that, even if it was not Hacking's intention, Hacking's argumentation seems to depend implicitly on analogical thinking: 'we see observable causes C_1, ... , C_n all of a certain sort producing similar observable effects E_1, ... , E_n; then we attribute a similar but unobservable cause C to a further observable effect E by analogy' (van Fraassen 1985, 299)

[3] Teller regards his comments not as an indication that something is fundamentally wrong in the distinction between observable and unobservable, but as pointing to the need of a better empiricist notion of phenomenon (Teller 2001, 133-4).

[4] The details of van Fraassen's argumentation are not necessary to the ideas defended in this paper. They involve taking into account types of phenomena that van Fraassen had not considered previously, like rainbows, and reflections in the water, and making a parallel with the images seen in a microscope: 'it is these images that are like the rainbow (they cannot themselves be represented as independent things)' (van Fraassen 2001, 157).

The main points of our discussion are not affected by just where precisely the line [between observable and unobservable] is drawn. I draw the line this side of things only appearing in optical microscope images, but won't really mind very much if you take this option only, for example, for the electron microscope. After all, optical microscopes don't reveal all that much of the cosmos, no matter how veridical or accurate their images are. *The empiricist point is not lost if the line is drawn in a somewhat different way from the way I draw it*. The point would be lost only if no such line drawing was to be considered relevant to our understanding of science. (van Fraassen 2008, 110)[5]

Again, in van Fraassen's response to Teller's worries we see that *van Fraassen recognizes that it is meaningless to try make a clear cut distinction between where observable ends and unobservable begins*. To him, as we have seen, this is not a problem. I will show next that this is not the case.

2.2 The argument: part 1

Let us return to Hacking's arguments. There is a crucial aspect related to microscopes that Hacking missed, even if he went close by. This aspect changes things completely and makes it possible to use ideas related to the ones by Hacking that are not undermined by van Fraassen's criticism.

As we have seen Hacking's coincidence argument spins around distinguishing real structural features from artifacts produced by microscopes; in particular, Hacking considers small dots in red blood cells that are seen using a low resolution electron microscope or a high resolution light microscope. The element I want to emphasize at this moment related to the argument is simply this: 'the low resolution electron microscope is about the same power as a high resolution light microscope' (Hacking 1983, 200). That is, there is a range where one is confident that both microscopes enable us to see the same little things. Why is one confident of that? I will answer in a moment. As we have seen, van Fraassen demises Hacking's argument as it stands, pointing to the fact that

we refer to two different sorts of instruments, so the sameness in the outputs must be attributed principally to similarities among the inputs. But no one doubts that it is in each case *blood samples* and not different kind of physical systems that were fed into the machines. This conclusion warrants no inference about the reality of the imputed unobservable structure. (van Fraassen 1985, 298)

Let us return now to Hacking's argument of the grid. As we have seen a barely visible disc of metal is supposed to be engraved with a (in van Fraassen's view, unobservable) square grid with letters in each square. According to Hacking, 'we look at the tiny disc through almost any kind of microscope and see exactly the same shapes and letters as were originally drawn on a large scale' (Hacking 1983, 203); and why is that? As we have seen Hacking presents a circular argument that van Fraassen correctly criticises.

What is missing in Hacking's account of microscopy is the key operational procedure called calibration. Loosely speaking, to calibrate an instrument is to follow an operational procedure that makes the instrument work in a similar way to another for a particular range. One example of calibration is that of different thermometers, so that they give the same temperature reading in a overlapping temperature range (Chang 2004). The same goes with microscopes. In this case *the microscopic grid (that we see with a light microscope) is used for the calibration of the electron microscope*. As William Seager called attention to, the microscopic grid is used first

for the detection and correction of aberrations in the [electron] microscope. That is, the electron lens of a microscope is adjusted to give the perfect grid appearance, and once the image looks sufficiently rectilinear, the microscope ... is

[5] This is a 'rephrasing' of van Fraassen's comments on Teller's views: 'I really don't mind very much if you reject this option for the optical microscope. I will be happy if you agree to it for the electron microscope. For optical microscopes don't reveal all that much of the cosmos, no matter how veridical or accurate their images are. The point of constructive empiricism is not lost if the line is drawn in a somewhat different way from the way I draw it. The point would be lost only if no such line drawing is considered relevant to our understanding of science' (van Fraassen 2001, 162-3).

pronounced fit for service. The grid is then used to calibrate the microscope so that accurate size measurements of new images are possible. (Seager 1995, 466)

In simple terms, if we are confident on the workings of the light microscope we can calibrate the electron microscope to it. And how can we be confident on the light microscope? Because, contrary to van Fraassen's criticism, Maxwell's intuition of a continuous series was in part right!

As we have seen, Maxwell basically presents without any argumentation the (for some) intuitive idea that there is a 'continuous series' (a term not really defined by Maxwell) that goes from seeing with the naked eye, seeing through a window or using glasses, seeing with an optical microscope, seeing with an electron microscope, and so on. The problem is that Maxwell does not provide any argument for what a 'continuous series' might be. Van Fraassen calls the attention to this point and makes the case that even if it is not possible to draw the line between the observable and the unobservable clearly it is possible to give clear examples of observable-to-us and unobservable-to-us that show, according to him, that the distinction between observable and unobservable is meaningful. In this way an apple is observable and an electron (if existing) is not. Contrary to Maxwell's realist argument we would have then an observable/unobservable dichotomy. *When considering a series of calibration procedures, it is possible to give a meaningful notion of a 'continuous series' that goes from naked eye perception to aided perception with a series of instruments, in this way recovering (in part) Maxwell's intuition regarding seeing with instruments.*

Scientific instruments of a particular 'class' are calibrated (between them and in relation to standard units) using a precise calibration procedure. As we have seen the putative micro-grid that is 'seen' with the optical microscope is used in the calibration of the electron microscope so that there is a range in which both microscopes gives similar/equivalent results/images/access to the 'unobservable'. *It is the calibration that creates the 'continuous series'*. Loosely speaking, we can calibrate the optical microscope with the visual capacities of normal members of the epistemic community (as we can use lenses to improve deficient visual capacities of 'non-normal' members). *It is this circumstance that enables us to avoid van Fraassen's criticism of Hacking arguments.*

In his criticism of Hacking's coincidence argument van Fraassen says that 'we refer to two different sorts of instruments, so the sameness in the outputs must be attributed principally to similarities among the inputs' (van Fraassen 1985, 298). That is not the case; *we are not considering different sorts of instruments but a particular class of instruments that are calibrated to our visual capacity and between them*. The same goes for the argument of the grid. It is not the case as Hacking says that 'I know what I see through the microscope is veridical because we *made* the grid to be just that way. I know that the process of manufacture is reliable, because we can check the results with the microscope' (Hacking 1983, 203). This is a circular argument as van Fraassen calls the attention to. However *the case is that we 'see' the grid with the optical microscope and we use it to calibrate the electron microscope, and this is not a circular operational procedure* (also we do not rely on any analogical thinking here).

It is true that while we can see the hind end of an ant there is a point beyond which we cannot distinguish details of the structure without the optical microscope. But, *there is a range in which we can check what we see with the optical microscope with what we see with the naked eye*. Van Fraassen does not provide an argument that shows there to be a relevant difference between the smaller structural feature a member of the epistemic community can distinguish and a more detailed view of these structural features only seen with the optical microscope. On the contrary, as we have seen, van Fraassen considers that it is not possible to make a clear cut distinction between where observable ends and unobservable begins, and that this 'line' can change if the epistemic community changes (e.g. if our species goes through biological changes that enhances our perception possibilities).

Contrary to van Fraassen's opinion it is relevant that it is not possible to draw the line between the observable and the unobservable clearly. There is a structural continuity in the features we see of the hind end of an ant with the naked eye and with the help of a microscope. There is no argument I

know of that shows that there is a discontinuity between what is barely distinguishable by us and what is not distinguishable by us; also there is no argument I know of that shows that an instrument that in the visible range is calibrated to our vision (and that enables, up to what is barely distinguishable by us, to see the same as in naked eye vision) has a discontinuity exactly at the border between the seeable-to-us and unseeable-to-us, so that after the discontinuity it does not provide anymore a way of seeing barely visible things but a way of making images that are not anymore a direct seeing through/with the microscope. *Since there is no convincing argument to the contrary, I consider that when calibrating the optical microscope to our vision we can extended our visual range into ranges beyond normal human capacity* (i.e. into what van Fraassen calls the unobservable).[6]

Contrary to van Fraassen's view, it really makes a difference if we consider that we see with an optical microscope. This is so because we can further extend the eye/glass/optical microscope 'continuous series' by calibrating the electron microscope to the optical microscope using for example the micro-grid (this can be done even if the question of what the grid really looks like does not have any meaning, since the answer would have to be made with an 'if': if the grid was somehow perceptible with the naked eye it would look like ...). Does this imply by itself the downfall of van Fraasen's dichotomy? I think not.

2.3 The argument: part 2

Let me recapitulate the results so far: we see with microscopes. Recalling van Fraassen's writings it might seem that his dichotomy is in danger. After all, van Fraassen considers that

> The main points of our discussion are not affected by just where precisely the line [between observable and unobservable] is drawn. I draw the line this side of things only appearing in optical microscope images, but won't really mind very much if you take this option only, for example, for the electron microscope. After all, optical microscopes don't reveal all that much of the cosmos, no matter how veridical or accurate their images are. *The empiricist point is not lost if the line is drawn in a somewhat different way from the way I draw it*. The point would be lost only if no such line drawing was to be considered relevant to our understanding of science. (van Fraassen 2008, 110)

In his argument against Maxwell's argument, van Fraassen clearly stated that even if there was no clear line between the observable and the unobservable, if it was possible to present clear cut cases of observable things and clear cut cases of unobservable things the dichotomy makes sense. Now, in relation to the first part of my argument: (1) does the previous result of a meaningful 'continuous' series of instruments breaks down the dichotomy? (2) is it not the case that van Fraassen's example of unobservable still stands even when accepting that electron microscopes enable us to see?

Let us return to Teller's views (Teller 2001). Teller made a clear distinction between different type of instrumentation, accepting van Fraassen's 'phenomena creation' view for most cases. Teller only made the case that there are some exceptions; one example being the optical microscope, which enable us to see beyond our 'bare' perceptual encounter with the world.

[6] It is correct to consider that beyond the range of human vision we do not have a criterion to say that we see the structure as 'it really is' or somewhat changed by the instrument (i.e. it is not possible to compare on any equal basis the large-scale 'real' grid to its putative microscopic scale reproduction). However I consider that we cannot think of micro-structures in terms of what they would look like if they where visually perceptible by us, since they are not. In some views related to scientific realism it is implicit the metaphysical idea of an ontological structure of the world characterized by a spatial scale and things in relation to which we can zoom in/out our 'perceptual encounter' with them while maintaining the thing's identity as seen by us (i.e. the idea that things can be seen scale independently, which has implicit the acceptance that the word 'thing' is meaningful independently of the spatial scale); for example Paul Churchland considers that 'for any microscopic entity, one can in principle always change the relative spatial *size* ... so that the entity is observed' (Churchland 1985, 40). However even from a realist position one is not enforced to accept this type of metaphysical views, and accepting that we have no instrument-independent way of seeing what is at the present time beyond our current perceptual range does not have to imply, in relation to our epistemic attitudes, a crucial difference between apples that we see directly or paramecia that we see with a microscope.

In the first part of my argument I am only extending Teller's view for a particular class of instruments that are calibrated between them and to our bare-vision. Importantly, the calibration series stops, i.e there is no undefined number of instruments; also we cannot calibrate this instrument class called microscopes (and they are so called because we can calibrate between them!) with other type of instruments like for example the cloud chamber, a clock, and so on. In this way, *for the majority of phenomena, one can maintain van Fraassen's views about instruments as creating new phenomena to be described by physical theories*.

Regarding van Fraassen's views of 'electrons' as unobservable-to-us, it seems that even granting that one sees with the help of an electron microscope, one does not sees 'electrons'. The most one could say, following entity realists, is that for example one is detecting electrons using a cloud chamber; after all we do not see with a cloud chamber (van Fraassen 1980, 17). At first sight it would seem that van Fraassen's example of unobservable is not problematic. This would imply that even when accepting that we see with microscopes van Fraassen's dichotomy would not be affected (contrary to van Fraassen's own views; see the above quotation of van Fraassen 2008, 110).

One could ask: why did van Fraassen come up with the dichotomy in the first place since one cannot expect to use microscopes to see electrons? I think the answer is in Maxwell's original argumentation of the continuum, in which Maxwell does not make any distinction between seeing and detecting, giving the impression that there is a 'continuum series' that goes all the way from seeing apples to detection electrons. This in my view induces van Fraassen to stipulate a new dichotomy to enable him to implement his anti-realist intuition against accepting putative theoretical entities. This confusion was made possible due to the fact that *neither Maxwell or van Fraassen took into account the calibration of scientific instruments, which gives us criteria to distinguishing between instrumental aids to our visual capacity (a class of these being called microscopes, which are calibrated between them) with different classes of instruments (like thermometers, which are calibrated between them)*. In any case, it seems that we would still be left with meaningful examples of observable things and putative entities that if existing would be unobservable.

It would seem then that when accepting that we see with microscopes one only has to rephrase van Fraassen's views, by making a fine-tuning in the words we use to define the dichotomy. Instead of just using the terms 'observable' and 'unobservable', one should give more details, making explicit the difference between 'observable (even if with the aid of microscopes)' and 'detectable (i.e. not observable with the aid of microscopes, but 'indirectly' detectable using complex instrumentation)'. We could even leave out the word 'unobservable', and talk about things, processes, and so on, that are observable or only detectable. However, as I will show next, this reformulation of the dichotomy, as the original formulation, is difficult to sustain when taking into account van Fraassen's own views regarding experimentation and the type of description provided by physical theories.

As we have seen, van Fraassen's example of unobservable is electrons. In this way, van Fraassen's dichotomy would still be valid even if in the need of more precision in what regards what we mean by observable. Is this really the case? I think not.

Why is the term 'electron' taken as a non-disputed example of unobservable, to the point of being the defining example of unobservable to van Fraassen? Why not take 'ghosts' as our example? 'Ghosts' are not part of the accepted cannon of science, however 'electrons', in a way or another, are. In some forms of realism it seems that 'electrons' are entities postulated by physics (van Fraassen 1980, 18); with the pair 'electron'-'unobservable' – which more than characterizing 'electrons' as unobservable is giving a definition in the form of a defining example of what we mean by 'unobservable' –, van Fraassen is playing the game of some realists and accepts that putative entities postulated in some realist readings of physical theories can be classified as unobservable-to-us (following the realist's own prescription according to which the electrons can only be detected and not observed). But *why should someone that does not accept the metaphysics of entity realism*

accept the putative entities as philosophically meaningful in defining a epistemologically important dichotomy? Are not 'electrons-as-unobservable-entities' as philosophically irrelevant for the present case as 'ghosts' if one does not accepts them metaphysically in the first place?

The basic point I am making is that if one does not endorse an entity realism for physical theories in the first place there is no basis for endorsing the idea of 'unobservable entities', and 'electrons-as-unobservable-entities' have the same philosophical cash-value as 'ghosts' when trying to promote a less ambitious epistemic attitude regarding physics when compared with realism.

One can arrive at this conclusion by considering the development of van Fraassen's own views on experimentation and physical theories. In *The Scientific Image*, van Fraassen, presents, what to some entity realists is an experiment to measure the electric charge of the electron, as 'filling in a value for a quantity which, in the construction of the theory, was so far left open' (van Fraassen 1980, 77). *To van Fraassen, Millikan's experiment does not consist in measuring/detecting a property of a putative unobservable entity*; on the contrary, to van Fraassen we assist to 'the continuation of theory construction by other means' (van Fraassen 1980, 77). For the case being made here the important point is that van Fraassen can give an account of the experiments without any need to accept a realist view dependent on accepting a putative unobservable: *if we do not need 'detectable' in our account of physical experimentation, we also do not need the putative unobservable that we detect, i.e. if we are doing something different from detecting some unobservable-to-us, we do not need to take stock on this putative unobservable.*

This account of the implications of van Fraassen's views on experimentation in *The Scientific Image* agrees with van Fraassen's later views on experimentation. As we have seen, according to van Fraassen, any instrument used in experimental research creates new observable phenomena:

> this is meant to be a change in view: assimilate those instruments as well, not to windows into the nether world, but to experimental arrangements that produce telling new effects for us to see and for us to give a place in our representations of the world. The instruments used in science can be understood as not revealing what exists behind the observable phenomena, but as creating new observable phenomena to be saved. (van Fraassen 2001 , 154-5)

There is in this account of experimentation (i.e. of what in some cases one might be tempted to call detection of properties of putative unobservables) no need of an account in terms of unobservables.

This perspective on experimentation, not relying in any way on the idea of unobservable, is reinforced by van Fraassen's latter structural empiricism (van Fraassen 2006). Now, van Fraassen is fighting structural realism. In this battlefield there is no place for unobservable entities. Structural realism does not defend the existence or epistemic relevance of unobservable entities. The slogan is 'structure is all that there is'. There are several variants to structural realism (see, e.g. Ladyman 1998), which I will not consider here since it not relevant for the case being made. According to van Fraassen

> there are ... only two sorts of things we deal with directly. These are the concrete, observable things, events, and processes in nature on the one hand and on the other hand, the abstract structures studied in mathematics. We characterize the structure of the former in terms of the latter. (van Fraassen 2006, 304)

> there are just two realms of scientific investigation, hand in hand by experimentalists and theorists. on the one hand there are the phenomena which are investigated. On the other hand there are the models, abstract structures studied in mathematics, which the theory advances as representations of those phenomena. (van Fraassen 2006, 304)

Crucially for the point being made here, van Fraassen considers that the only structure described by the theory is empirical structure, and not an 'underlying' structure that enables us to have knowledge about 'features of the reality behind the phenomena' (van Fraassen 2006, 277), as some structural realists believe. To van Fraassen a new superseding theory does not have to share a theoretical/abstract structure with the superseded theory, i.e. a new theory can describe the phenomenal structure in a 'quite different, theoretically novel way' (van Fraassen 2006, 302). This is

because to van Fraassen there is no theoretical structural continuity between related theories (like, e.g., between Newton's and Einstein's gravitation theory), *there is only phenomena and the mathematical structure that represents it. There is no account in terms of unobservable entities: the concept of 'unobservable' is not necessary to van Fraassen's account of structural empiricism.*[7]

In a nutshell: the first part of the argument related to microscopes shows that van Fraassen observable/unobservable dichotomy cannot be maintained in its original formulation of an perceptible/unperceptible distinction. As mentioned in the second part of the argument, one could try to implement the dichotomy as a observable/only-detectable distinction. However *we need from the start to accept conceptual constructs like 'unobservable', 'electrons-as-unobservable-entities', or 'detectable', and there is no non-metaphysical justification to consider 'electrons' (like 'ghosts') as a clear cut case of 'unobservable' that can be 'detected'*. By accepting for example van Fraassen's structural empiricism or some form of structural realism one lacks metaphysical support for this view. Under these circumstances the observable/unobservable dichotomy looses its philosophical strength for justifying a particular epistemic attitude. Possibly van Fraassen can justify the epistemic attitude set forward in *The Scientific Image* by resort to his structural empiricism without any need for the dichotomy. However this is a issue well beyond the limited scope of this work.

3 Conclusion

In my view the observable/unobservable dichotomy was set forward by van Fraassen to solve an unexisting problem. As mentioned van Fraassen constructive empiricism was constructed as a critic to entity realism and is inadvertently dependent on the previous in setting forward is arguments. Van Fraassen felt the need for the dichotomy as an answer to Maxwell's loss argument that seemed to make possible to see/detected for example electrons. As we have seen *we do not need the observable/unobservable dichotomy to prevent the possibility of seeing theoretical entities that according to entity realists might be out there; it is only necessary to understand that we cannot calibrate a microscope with a cloud chamber!* In my view, when setting forward his alternative view on experimentation – like the Millikan experiment, that to entity realists enables to 'measure/detect' the charge of the 'electron' –, *van Fraassen does way with the word 'detection', and by doing this makes it unnecessary to think in terms of unobservable-to-us*. His latter work confirms this tread. *Be it the 'phenomena creation' view or 'empirical structure is all there is' view, the terminology of 'detection' and 'unobservable' is nowhere to be found*; and this is because in structural empiricism (as in structural realism) the unobservable as discussed in *The Scientific Image* has no place.

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[7] With this view of experimentation and theoretical description, 'electrons' can be seen as mere theoretical terms, i.e. part of the internal machinery of a theory that we might, for theoretical or practical reasons or even habit, use in colloquial language associated to the application of the theory, as if 'electron' meant a sort of very little billiard ball with some 'strange quantum behaviour'.

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